LANSCE
Los Alamos Neutron Science Center

Research Proposal for the use of Neutron Science Facilities

☐ **Fast Access** ☐ **Joint CINT Proposal**

Proposal Number: 20111559
Submission Number: S1580
Date Received: 03/14/11

Program Advisory Subcommittee: Nuclear Technology
Focus Area:

Flight Path/Instrument: 1FP14 / DANCE
Dates Desired: 2 days early in June-July, 2010
Estimated Beam Time (days): 5
Impossible Dates:
Days Recommended: 0

TITLE
Characterization of gamma-ray emission from neutron capture on Gd and Cd

☐ Continuation of Proposal #:

☐ Ph.D Thesis for:

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RESEARCH AREA

- ☐ Biological and Life Science
- ☐ Chemistry
- ☐ National Security
- ☐ Earth Sciences
- ☐ Engineering
- ☐ Environmental Sciences
- ☒ Nuc. Physics/chemistry
- ☐ Astrophysics
- ☐ Few Body Physics
- ☐ Fund. Physics
- ☐ Elec. Device Testing
- ☐ Dosimetry/Med/Bio
- ☐ Earth/Space Sciences
- ☐ Materials Properties/Test
- ☐ Other:
- ☐ Mat'l Science (incl Cond Matter)
- ☐ Medical Applications
- ☐ Nuclear Physics
- ☐ Polymers
- ☐ Physics (Excl Condensed Matter)
- ☐ Instrument Development
- ☐ Neutron Physics
- ☐ Fission
- ☒ Reactions
- ☐ Spectroscopy
- ☒ Nuc. Accel. Reactor Eng.
- ☐ Def. Science/Weapons Physics
- ☐ Radiography
- ☒ Threat Reduction/Homeland Sec.
- ☐ Other:

FUNDING AGENCY

- ☐ DOE/BES
- ☐ DOE/OBER
- ☐ DOE/NNSA
- ☐ DOE/NE
- ☐ DOE/SC
- ☒ DOE/Other
  NA-22
- ☐ DOD
- ☐ NSF
- ☐ Industry
- ☐ NASA
- ☐ NIH
- ☐ Foreign:
- ☐ Other US Gov't:
- ☐ Other:

PUBLICATIONS

Publications:

NONE

Abstract: S1580_LANSCE_CdGd_.doc

By electronic submission, the Principal Investigator certifies that this information is correct to the best of their knowledge.

Safety and Feasibility Review *(to be completed by LANSCE Instrument Scientist/Responsible)*

☐ **No further safety review required** ☐ **To be reviewed by Experiment Safety Committee**

☐ **Approved by Experiment Safety Committee, Date:**

Recommended # of days:	**Change PAC Subcommittee and/or Focus Area to:**	**Change Instrument to:**

Comments for PAC to consider:

Instrument scientist signature: **Date:**

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Characterization of gamma-ray emission from neutron capture on Gd and Cd

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Summary: We request 5 days of beam time at flight path 14/ DANCE to measure neutron capture gamma-ray cascades from ^{nat}Cd(n,g) and ^{nat}Gd(n,g)

Motivation

The Gd and Cd isotopes have the largest neutron capture cross sections for thermal neutrons. Many nuclear application benefit from these large cross sections to attenuate the neutron flux. However, advanced neutron detector research and development can use the gamma-rays that follow neutron capture on these isotopes to detect neutrons. Such detectors can be used in portal monitors of strategic nuclear material. However, existing data on gamma-ray emission following neutron capture lacks the information on correlated data, e.g. information on the gamma-ray capture cascade. It is highly desired to measure and interpret the matrix of gamma-ray multiplicity versus gamma-ray energy. In this proposal we would like to measure such correlated data for Cd and Gd using the DANCE array at flight path 14. We successfully succeeded these type of measurements in the past. The experimental results were usually interpreted using the simulation of the capture gamma-ray cascades followed by the simulation of the DANCE array in GEANT4 to account for the DANCE gamma-ray detection response. The GEANT4 simulation of the DANCE array is well calibrated using gamma-ray sources. Therefore using a trial and error approach, we will find the best model parameters for the statistical de-excitation codes to fit the measured data – the main sensitive parameters of these model are gamma-ray strength functions and nuclear level density. It is worthwhile to mention, that many applications may benefit from the measured data directly without improving the measured data through simulations.

Targets and Measurements

As opposed to cross section measurements, the targets for these measurements do not need to be well characterized and it is sufficient to know the approximate total mass of the targets. In case of thick targets however, we need to understand the geometry and thickness of the sample to simulated the gamma-ray attenuation. The detailed knowledge of the neutron flux is not required.

The measurements will be performed for resonance region above 0.4 eV and for thermal.

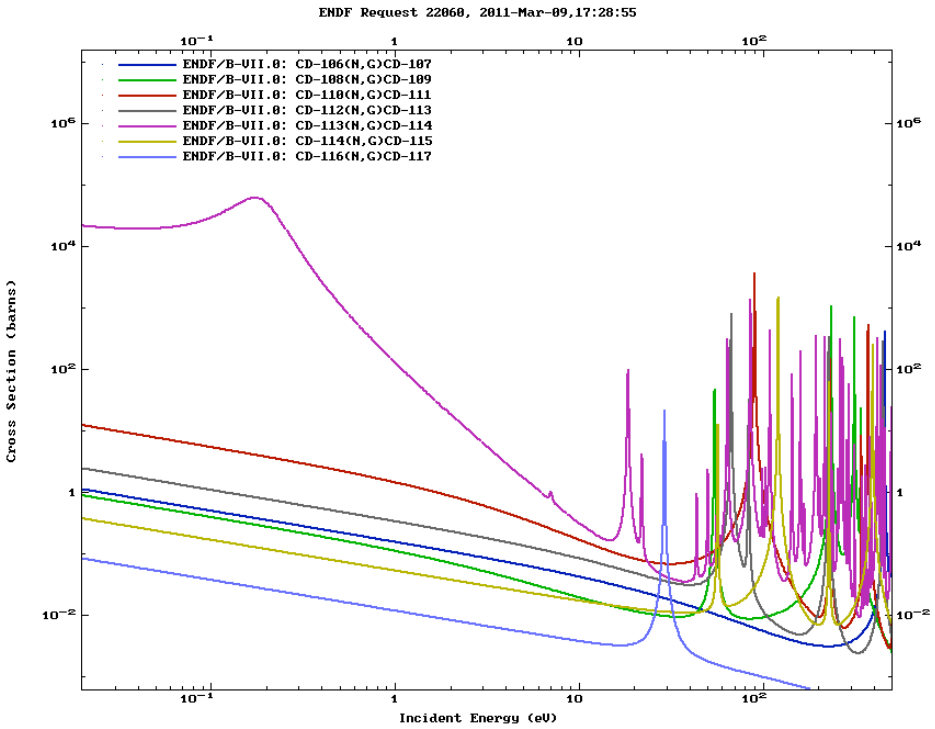

Figure 1 Neutron Capture cross sections for isotopes of Cd from thermal energy to 500 eV.

a) Resonance region: We will use the pressed 5-7 mm diameter targets with the areal mass of tens of mg/cm2 for the measurements in the resonance region. For these measurements we will use the Cd filter to remove neutrons below 0.4 eV from the neutron flux.

b) Thermal neutrons:
For the measurements at thermal energies we will use thin electroplated targets prepared at C-NR with the thickness of ~1 ug/cm^2.

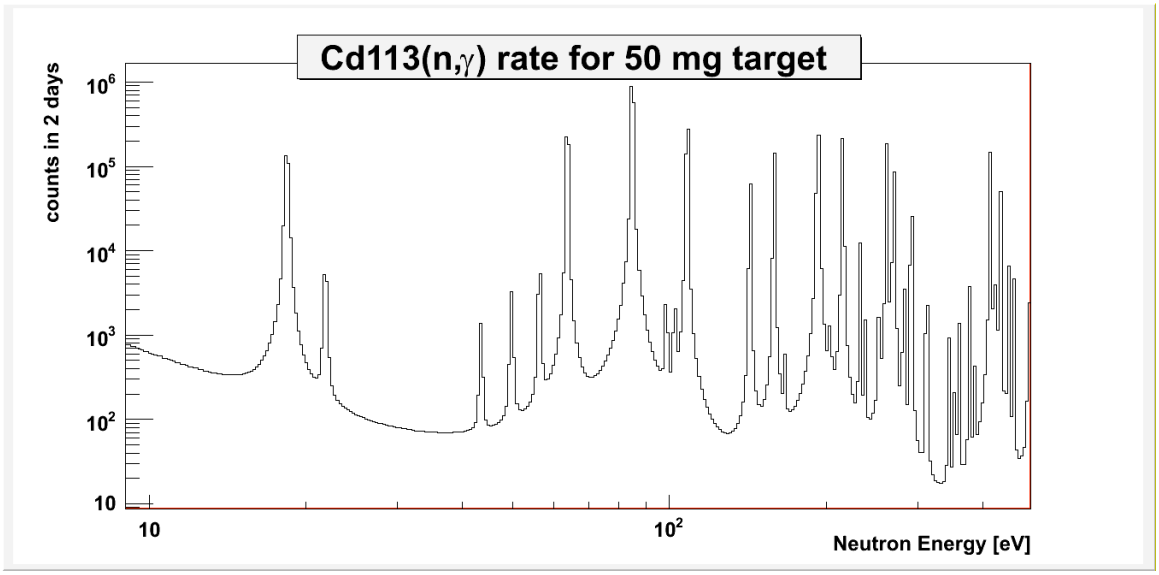

Figure 2 Expected count rate from Cd113(n,g) reaction using 50 mg natCd target (12% of 113Cd

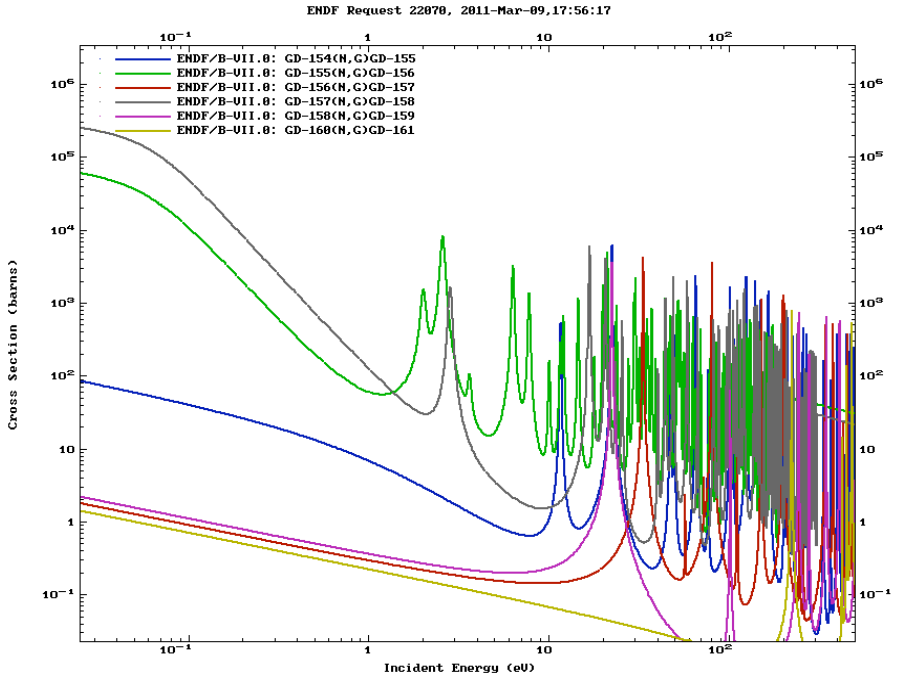

Figure 3 Neutron capture cross section for the isotopes of Gd from thermal energy to 500 eV.

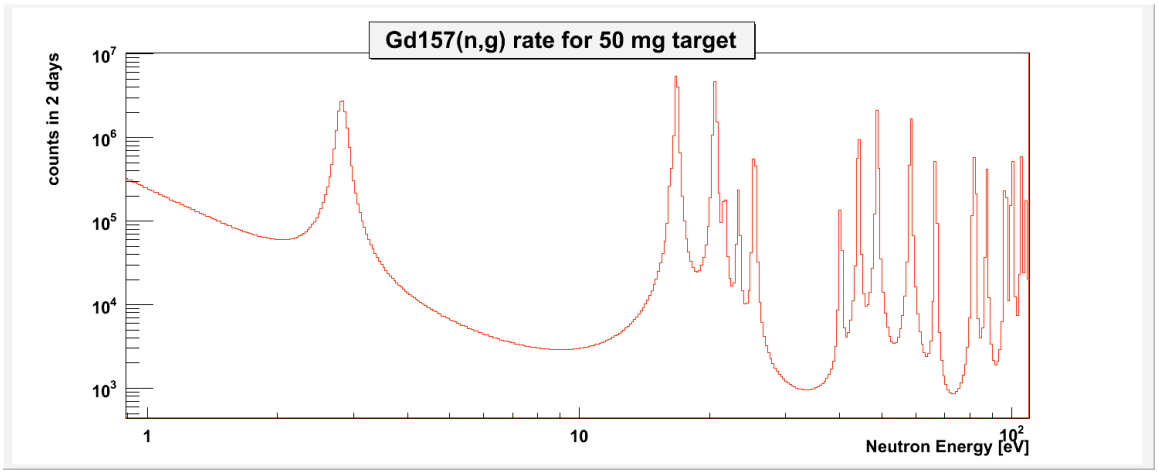

Figure 4 Expected count rate from Gd157(n,g) reaction using 50 mg ^{nat}Gd target (15% of ^{157}Gd abundance in the natural Gadolinium was assumed)

The neutron capture cross sections for Cd isotopes are shown in Figure 1. The Cd-113 isotope has the largest thermal cross section. We estimated rates due to the neutron capture on this isotope for the 50 mg thick pressed ^{nat}Cd target, assuming two days of beam and 12% abundance of Cd-113 in the natural Cadmium. We will prepare targets of several thicknesses to avoid attenuation effects and pile-up effects.

Similarly, for Gd, isotopes Gd-155 and Gd-157 have the largest thermal cross sections – see Figure 3. The expected rate in the resonance region is shown in Figure 4 for Gd-157 for two days long measurement assuming 50 mg thick target.

Beam time request

We request 5 days of the beam time at flight path 14.
We would like to use first two or three days in June 2010 and then continue these measurement later by the end of the year 2010. There is a possibility that auxiliary HPGe detectors will be added to the DANCE array in late 2010, and we would like to use these detectors to measure spectroscopic information on the capture cascades for these materials.